GREAT ARTESIAN BASIN SPRINGS IN SOUTHERN QUEENSLAND 1911-2000

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Fairfax, R.J. & Fensham, R.J. 2003 06 30: Great Artesian Basin springs in Southern Queensland 1911-2000. *Memoirs of the Queensland Museum* **49**(1): 285-293. Brisbane. ISSN 0079-8835.

This study presents descriptions of Great Artesian Basin springs in south-central Queensland from 1911-1912. It compares these records with a second survey conducted in 1999-2000. Of 58 springs documented in the initial survey, 42 were inactive and 13 active in the year 2000. Three were not re-located. Observations concerning fluctuations in spring flows, causes of spring inactivity and wetland vegetation are provided. ❒ *Great Artesian Basin, bores, springs, Queensland, history.*

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The Great Artesian Basin (GAB) lies beneath much of the semi-arid land in northeastern Australia (Fig. 1) and is the continent's most voluminous aquifer. The Basin is charged by rainfall that enters porous sedimentary sandstones outcropping along the Great Dividing Range (Habermehl, 1982; 2001). Water naturally exits the aquifer within these recharge areas as 'recharge-rejection springs' and as 'discharge springs' on the lower, inland margins of the basin where the age of the water may exceed 800,000 years (Radke et al., 2000). GAB springs are regionally clustered and referred to as spring Super-groups (Fig. 1). For the purposes of presentation the term Spring-group is used to represent multiple vents/springs where no adjacent pair of springs is more than about 1km distant. Spring-groups are often referred to by the place name 'Springs' e.g. Baroona Springs. 545 Spring-groups have been documented from Queensland (Fensham & Fairfax, in press).

Individual GAB springs have been recorded as discharging a few to several million litres of water per day (Habermehl, 1998; Fensham & Fairfax, in press), corresponding to muddy areas of a few square metres to permanently flowing streams. Many of the wetlands contain flora and fauna endemic to GAB springs, notably fish, plants, snails and other invertebrates. Some species such as the Elizabeth springs Goby (*Chlamydogobius micropterus*) have only been recorded from one isolated Spring-group and numerous other endemic species are limited locally or regionally (e.g. Ponder & Clark, 1990; Ponder, 1986). Some springs are conspicuously mounded (to 6m high) due to the accumulation of discharged-mineral matter. Such mud springs generally do not support vegetated wetlands and in Queensland are most common in the Eulo Super-group.

Artesian bores first tapped the GAB in the late 1870's. Since then over 5,000 flowing bores have been sunk: the pressure within the Basin has dropped and currently about half of the bores still flow. Directly related to this reduction in artesian pressure (referred to as 'draw-down') about two-thirds of Queensland springs in the discharge areas no longer flow (Fensham & Fairfax, in press).

The Queensland portions of the Eulo and Bourke spring Super-groups form the current study area (Fig. 1). The region can be considered as semi-arid, with an average mean annual rainfall at Eulo in the order of 332mm/yr (Clewett et al., 1994). These Super-groups lie within the Warrego GAB Hydrologic Zone in which the average pressure head has decreased by 39m (range 0-120m) since development of the GAB (GABCC, 1998). This zone has the greatest loss of pressure within the GAB. Springs from the Eulo Super-group currently discharge about a third of their early 20th Century output of 1.6ML/day, 62% of 116 Spring-groups have become completely inactive and a further 14% partially inactive (Fensham & Fairfax, in press). That study found no inactive springs from the Queensland portion of the Bourke Super-group, although Pickard (1992) reports that 15 of 45 springs were extinct from the NSW portion.

Three of the four GAB spring endemic plants in Queensland (*Myriophyllum artesium*, *Sporobolus pamelae* and *Eragrostis* sp. RJ Fensham 3705) were recorded from the Eulo Super-group in 1999/2000. The endangered salt pipewort *Eriocaulon carsonii* was recorded from this area (Queensland Herbarium, unpubl. data) as well as from one spring in the NSW portion of the Bourke Super-group (Pickard, 1992). Several species of GAB endemic snails and isopods have also been recorded from Eulo springs (W. Ponder, pers. comm.).

The dramatic decline in spring flows and threatened GAB spring-dependent fauna and flora confer great conservation value upon remaining springs. The biggest threat to the water source, i.e. draw-down of the aquifer, is being addressed by a program to cap remaining flowing bores and improve the efficiency of water use (e.g. GABCC, 1998). In some areas where this has happened there are signs that the output of both springs (Fensham & Fairfax, in press) and bores (GABCC, 1998) has increased. Opportunities to rehabilitate springs (e.g. revegetation) may present themselves in the future. However, our knowledge of spring wetlands prior to their demise is poor and unrecorded. One written historical source is the reports of artesian bore inspectors in the late 19th and early 20th Centuries. Although focusing on the condition and output of bores these surveyors also briefly described the physical characteristics of springs (e.g. size and flows) and modifications (e.g. wells and bores) made to them (Fairfax & Fensham, 2002). Such descriptions enable a comparison between past and present, and provide a benchmark for which spring recovery can be gauged.

This article summarises various aspects of springs described within a survey of artesian bores and springs conducted in 1911-1912. Descriptions from that survey are compared with another field survey conducted by the authors in February 1999 and August 2000, in which a spring was considered active if it was wet at the ground surface or wobbled when jumped upon. A spring was also considered active in the case of wells when water was visible regardless of depth below ground surface. Thus our definition of 'active' does not imply that the spring maintains a natural wetland. Limitations and insights of the original survey information and changes in spring activity over the last century are discussed. The current activity of these springs has been collated within the broader study of Fensham & Fairfax (in press).

THE 1911-12 SURVEY

The first survey was conducted by C. Ogilvie and E. Edwards between October 1911 and April 1912, and documented within the handwritten, unpublished Artesian Reports Volumes VIII, IX and XVI held by the Queensland State Archives (reference numbers RSI 3037-1-8, 9 and 16). Within these reports the locations of most springs are either described or mapped with sufficient detail to enable their relocation.

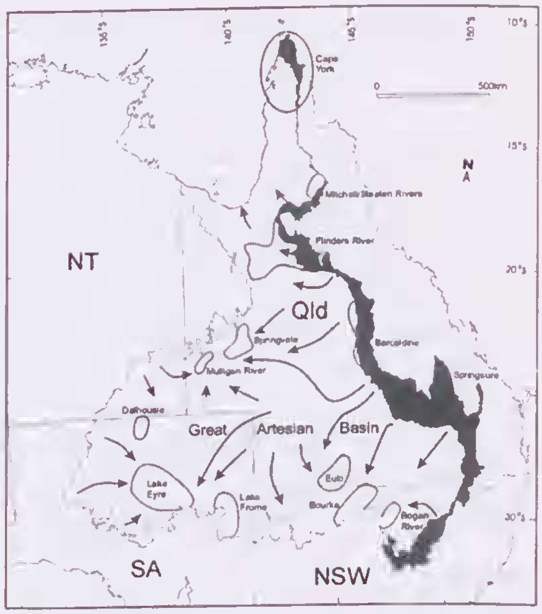

FIG. 1. Map of the GAB based upon Habermehl & Lau (1997). The shaded pattern represents the recharge area; arrows represent modeled flow lines after Welsh (2000). Dashed lines represent spring Super-groups adapted from Habermehl (1982).

Ogilvie & Edwards' 1911-12 survey recorded 56 separate springs (at least 48 Spring-groups) within the Eulo Super-group (Fig. 2; Table 1). Six of these were not surveyed as they were considered 'unimportant'. It can be assumed that these springs were dry or had particularly negligible flows. The descriptions of three groups suggest they were completely dry and may have been inactive prior to the first artesian bores in the district (1890's). Flows (gallons per day) were estimated for 22 springs. The survey was not comprehensive, as a further 68 Spring-groups were located for that district from other historical sources and field surveys during 1999 and 2000 (Fensham & Fairfax, in press). Ogilvie and Edwards also described two Spring-groups within the Bourke Super-group, approximately 200km east of the Eulo springs (Fig. 2; Table 1).

The descriptions were concise and largely restricted to the nature of modifications made to the springs to facilitate either greater flows or

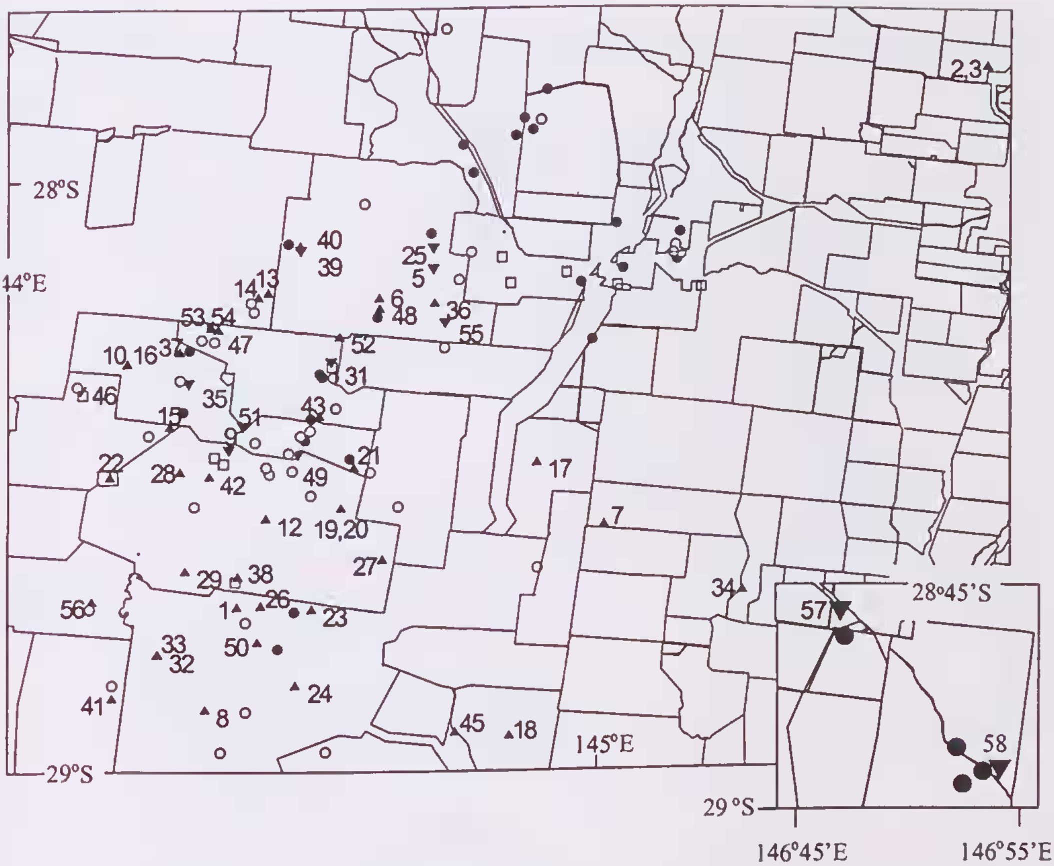

FIG. 2. Map of the Eulo district showing springs active in 1912 and 2000 (▼); active in 1912 and inactive 2000 (▲); other inactive Spring-groups 2000 (○); other active Spring-groups 2000 (●), and Spring-groups in 2000 containing both active and inactive springs (□). The latter 3 categories comprise springs not surveyed during 1911-12. Numbers correspond to springs listed in Table 1. Approximate current property boundaries are shown. The inset portrays springs within the Bourke Super-group. All springs represent Spring-groups except 2 and 3, 10 and 16, 19 and 20, and 53 and 54.

access to clean water. Indeed, it was mainly those springs with improvements that were visited and described; springs that could not be made to yield useful amounts of water were considered unimportant and generally not visited (Table 1). No mention was made of evidence of use of springs by Aboriginals (Robins, 1998) or native fauna associated with the springs. However, incidental notes included observations on fluctuations in spring flows, causes of some spring inactivity and broad botanical references (Table 1).

DISCUSSION

The work of Ogilvie and Edwards provides the earliest known benchmark from which GAB springs of southern Queensland can be assessed. At least three of the 56 springs documented from the Eulo Super-group were inactive when this survey was conducted around 1912. Following re-survey in 1999-2000, 42 (75%) had become inactive and 11 remained active to some extent. Three springs were unlocated in 1999- 2000 because their locations were not described in the original survey. Although not all springs within the Eulo Super-group were documented in 1911-12, the level of spring extinction revealed by this study is similar to the more comprehensive survey of that Super-group by Fensham & Fairfax (in press): 24% of Spring-groups active, 62% inactive, and 14% with both active and inactive springs. The two Spring-groups

TABLE 1. Summary of spring descriptions, use, flows, modifications made to them by 1912 and water taste. Bore flows were sourced from Dunstan (1913). gpd=gallons per day (1 gallon = 4.536L). A=active, X=inactive.

Spring(S) Name	No.	Abridged Spring Description	Human Use, Quality to Taste (1911-1912)	Flow (Gpd)	Developments	1999-2000 Status
Eulo Supergroup						
Barb	1	Several acres containing a number of dry mounds				X
Baroona (1)	2	One large flowing and several smaller non-flowing vegetated peaty springs; clumps of tall rushes, miranda (Typha spp.) 'Rankin [the lessee] says the flow seems to slacken during summer, but this is rather doubtful evidence as the total overflow is only about 500 gpd and this could readily be evaporated from the damp ground surrounding the well and consequently not reach the claypan about 30 yards distant.' 'The springs are stated to be independent of local rainfall for several years at least.' '…this spring watered about 4000 cattle during a drought in the early days of Tinnenburra Run but this is certainly excessive as its maximum flow at the bottom of the well is only 4110 g.p.d…'	Cooks Galley, Shearer's Hut; fair	4610	Well, pump, troughing	X
Baroona (2)	3	A few overflowing and about a dozen smaller vegetated springs; whole surface thickly coated with duckweed, mosses, rushes and other vegetation		1000	Pump	X
Bingara (old HS)	4	A single mud spring	Travelling public; good			X
Bingara (HS)	5	Four small improved springs and two large wet non-flowing mounds	Homestead; good	500	Wells	A
Bingara Springs	6	30-40 acres of dry mounds and wet mud springs		Small	Bore (40,000 gpd), unspecified improvements	X
Bitherty	7	1 dry and 1 wet mud spring with no evidence of recent overflow. An Acacia bush locally regarded as a sign of subterranean water present		Exceptionally large	Well	X
Bokeen	8	Unspecified, 'unimportant'	Outstation, boundary riders; good		Well, pump, troughing	X
Boomerang	9	Unspecified, 'unimportant'				A
Unnamed (Boorara)	10	A group of mounds up to 18 foot high practically all dry				X
Boorara	11	Scattered group of dry mounds 4-6 feet high		small		?
Boorara Woolshed	12	Single wet mud spring	Woolshed		Well, bore (17,000 gpd)	X
Bullenbilla (1)	13	About 20 mud mounds all wet at the surface, 6 overflow slightly and form small patches of green feed		500	Bores	X
Bullenbilla (2)	14	5 very large mounds (1 wet at surface) and 2 small carpet springs		5	Excavated	X
Burtanya	15	Unspecified, 'unimportant'				X
Bush	16	2 main improved springs and several smaller, one of which supplies a pool 10 foot diameter by 6 inches deep; very dense clump of reeds at troughs			Two wells, troughing, bore that yielded 9,000 gpd in 1901; dry by 1913	X
Caiwarro Mud	17	'When visited none of the springs were actually flowing, although 7 mounds were wet and boggy. There are altogether about 13 mounds, the biggest of which is about 8 ft high and not running. I am led to believe that the springs occasionally overflow, but there is no regularity in the periods of discharge'.				X
Caiwarro Bore	18	Small mud spring			Bore (25,000 gpd)	X
Colanya bore	19	Small spring			Bore (75,000 gpd in 1913; 90,000 in 1901)	X

TABLE 1 (*Cont.*)

Colanya springs	20	1½ miles of mounds to 15 feet high, some are wet and overflow, a few permanent holes; wells overgrown inside and out with reeds	Good	1600	3 wells, troughing	X
Corina	21	150-200 mostly dry mounds (extending about 2 miles) 5-20 feet high		200	Reservoir, troughing	X
Curracunya	22	A few acres of boggy flat, springs do not overflow to any extent	Homestead, pub		Well	X
Currawinya	23	A few mounds scattered within 1 mile diameter, 1 overflows slightly			Tank	X
Currawinya Station	24	Unspecified; possibly containing a small bamboo (Phragmites australis)	Homestead; excellent	600	Well	X
Dewalla	25	2 large (the main spring discharges into a grassy bog 1 chain wide), some smaller mud springs free of growth & several dry mounds	Travelling public; excellent	500	Unspecified improvement plus bore	A
Fish	26	Group of dry mounds plus several small active; like Umatcha Springs	Fair	100	Excavated	X
Goonerah	27	Isolated mud spring	Outstation; good		Unspecified improvement	X
Gooning	28	1 large, wet patches/pools (to 12 ft diameter) & several minor in vicinity. Free of odour and taste despite a dense growth of reeds around the spring	Station (dry season); excellent	1500	Well, pump, tanks, reservoir	X
Gourminya	29	Unspecified, 'unimportant'				X
Gowerah	30	Unspecified, 'unimportant'				?
Horseshoe/ Twomanee	31	'These springs (7 main) form practically one group round the granite outcrops. On the first visit to Twomanee which was in the middle of a summer's day (14/12/11) no well-defined springs could be found. On this visit however at 8am distinct flows were noticed in places that were merely wet patches on the previous occasion. It appears from these observations that the flow is not constant throughout the day though the falling off would be more noticeable in mid summer when the evaporation is a maxim' 'In most of the springs the evaporative effect is very marked, and especially at the main Horseshoe Spring. Here the water issuing from the bog surrounding the spring (during a week's inspection) appeared to advance and recede with comparative regularity according to the time of day; reaching approximately 1 chain further at 8am than at 5pm (when it began to advance). The effect was more marked on the very hot days so that observations taken at different periods might be expected to disagree'.		15000		A
Kapongee& Kapingee	32	Unspecified				X
Kaponyee	33	Unspecified, 3rd best spring in district		3rd big		X
Kungie	34	Boggy ground that never discharges any water, not mud-spring like				X
McNichols	35	A few scattered mounds, 'unimportant'				A
Nowanee	38	Unspecified, 'unimportant' (largest group in district)				X
Mingeburra	36	Two small groups of non over-flowing springs 'Since the bore was put down, he [J.G.Cooney, driller and selector] says that several of the springs have dried up, and it is now safe to ride across a flat which was originally very boggy'.	Good		Excavated, bore	X
Myrton	37	Mounds 2-7 ft high, a few discharge small quantity of water. Surplus from the bore forms a small swamp overgrown with reeds peculiar to the spring			Bore	X
Ooliman (at bore)	39	Grassy bog 20ft wide plus smaller dry springs 'This includes a flowing spring, which yields about 1500 gallons of good quality water per day. This spring is west of the bore and cool. The other members of the group are now dry but formerly yielded water before the interference referred to in Ooliman bore notes co-incident with the sinking of that bore'. 'A few dry springs belonging to this group lie about 3 chains north of the bore and in the crater of one of these Edwards found a sample of fairly rich copper ore, which had evidently been thrown up during an 'explosion' of the spring.'	Good	1500	Bore (28,000 gpd)	A

TABLE 1 (*Cont.*)

Ooliman (at hut)	40	Two main springs and a few non-flowing improved mounds 'It was this group that was reported to have failed on the completion of Ooliman bore. It is situated about 1 mile south west of the bore…'	Outstation; 1st Class	112	Wells plus troughing	X
Talaroo bore	41	Unspecified			Bore (75,000 gpd)	X
Tareen	42	A small flowing spring	Homestead; good		Well, troughing, pump, tank	X
Tarko	43	Largest group of mounds in district (extending 3 miles). 3 main fluwing springs, a few seattered wet patches of sand, some wet and overflowing mounds, main spring no longer used and overgrown with reeds	Travelling public; excellent	3000	Troughing, excavation	X
The Springs	44	A small group of mud springs not overflowing			Tank	?
Thorlinda	45	Group of unspecified springs			3 wells and bore	X
Tilberry	46	2 flowing springs and a few dry mounds	Outstation	1110	Well, troughing, pump, tank	A
Tunca	47	Group of springs of unspecified character		150	Well	X
Tunga	48	Unspecified '…since sinking Tunga bore the flow has stopped and the ground is almost dry'.		Fairly large	Bore (20,000 gpd)	X
Tungata	49	About 50 large dry mounds and 2 overflowing springs; growth of tall reeds	Good	1100	Well, excavation, troughing	A
Umatcha	50	A group of dry mounds to 20ft high & 100ft diameter over several acres				X
Wanko	51	Unspecified, 'unimportant'				A
Wiggera	52	Best in district, one large (flows for 3 miles) and several carpet springs. A few reeds flourish on the edge of the pool & good feed in the watercourse 'The supply is now very small hut a boundary rider who was on the run before the adjacent bore was sunk states that the spring gave out when the bore first struck water. Originally the spring maintained the same length of drain as the bore now does. [Water] Quality: excellent'.	Good/excellent	42100	Truughing, excavation, bore	X
Wirrarah (Wererah)	53	A group with one flowing spring and 12 wet mounds are 1mile southeast 'The fluw was originally, judging from the description of one of the station hands, about 10000 gpd, but now it does not exceed 200 gpd (difficult to estimate exactly)'.	Good	10000	Well, bore	X
1m S of Werrerah	54	12 mounds wet at the surface but non-flowing				X
Wooregym	55	A group of springs in an area about 220 by 110 yards. Other springs not improved give off large quantities of gas (as does Wiggera)	Homestead; good		6 wells, bore (48,000 gpd) in near vicinity	A
Youleen (Youlain)	56	2nd best in district, 2 main and several smaller springs, 5 acres of swamps, growth of green grass, water temperature 103°F, cold spring unlocated	Good	30000-40000		X
Bourke Supergroup						
Tego	57	A small group of mud springs 'Robertson (Tego) states that the discharge apparently does not fluctuate during the various seasons, but of course the effect of evaporation in summer causes the general appearance to alter'.		200	Well, tank, dam	A
Towry	58	Boggy areas, bogs and pools plus ½ mile2 of small springs. Patches of water grass, bog of miranda (Typha spp.) 'The discharge does nut vary with the seasons and the springs are a fairly regular watering place'.	Usual	700	Excavated, bores	A

surveyed in the Bourke Super-group in 1911 contained active springs in 1999.

Some of the currently inactive springs are mounded mud springs that previously flowed relatively small quantities of water. However, larger springs have also stopped flowing, including the largest three surveyed: Wiggera, Youlain and Kaponyee Springs (Table 1). Other springs had ceased to flow altogether by 1912 (e.g. Mingeburra, Ooliman, Tunga), and Ogilvie & Edwards documented that some springs, such as Werrerah Springs had greater flows prior to bores being sunk (Table 1). The original spring flow estimates and descriptions should therefore be treated as underestimates of the pre-artesian bore era.

Many bores were sunk adjacent to springs. For example, from Bingara and Dynevor Downs runs Ogilvie and Edwards recorded that 'All the bores on the runs, 6 running and 3 abandoned, were put down within a few yards of mud springs ...' Dunstan (1913) noted that some bores on runs that contained springs, including Dynevor Downs had reduced flows within a few years after they were sunk (Table 1). Several of the bores in the district initially flowed more than 10ML/day, and recent bore-flow measurements are 10% of the original estimates (Table 2). The large flows from bores and their proximity to springs almost certainly accounts for the observed reduction in spring-flows. None of the springs active in 1999-2000 appear to have increased in flow since 1911-12.

It is important to consider natural fluctuations in spring flows when assessing longer-term changes in flow rates (e.g. Williams & Holmes, 1978). Ogilvie & Edwards report that Towry Springs had a constant flow rate, the flow of Horseshoe/Twomanee fluctuated with daily evaporation and the flow from Tego Springs did not apparently fluctuate between seasons although a summer evaporation effect was evident (Table 1). However, in most cases such changes would have been inconsequential compared to estimated flow rates and spring activity. Irregular discharges from mud springs were recorded for Caiwarro and an occasional 'explosion' was reported for Ooliman Springs (Table 1). This is consistent with anecdotes from landholders regarding mud spring activity collated during the 1999-2000 survey. Some large springs have only become inactive in recent decades. The habitat notes on a Queensland Herbarium specimen of *Cyperus laevigatus* indicate that Kaponyee spring was active in 1971 and a local resident has confirmed that Wiggera spring was active in the 1960s (I. Pike, pers. comm.).

Two-thirds of all springs recorded by Ogilvie & Edwards had been modified in some way prior to 1912, mostly by constructing wells. Wells were often boxed (lined) to a level above the natural outlet of the vent thus eliminating any wetland associated with the spring.

At least 10 of the 14 Eulo Super-group springs whose descriptions included references to vegetation have become inactive. Of the remaining four, two wetlands are supplied by abandoned bores (Ooliman & Dewalla), one has been decimated by stock (Tungata) and Horseshoe has been excavated to form a small dam. None of the 14 contained GAB endemic plants during the recent survey. Descriptions such as bogs, swamps, peat and carpet springs were applied to seven springs (Table 1). Such descriptions are compatible with situations in which GAB endemic plants have been observed, both in the Eulo district and elsewhere in the GAB (Queensland Herbarium unpub. data) and may represent former habitat. Wiggera Springs was the largest spring in the district and described as comprising carpet springs. A local resident recalls the endangered *Eriocaulon carsonii* from that spring when it was active (I. Pike, pers. comm.).

This study provides further evidence of the impact of bores on springs. The positive news is that examples exist from within the study area of increased artesian pressure since the bore-capping program (GABCC, 1998). Thus completion of the bore rehabilitation program and judicious prioritising of GAB water use may enhance flows for remaining springs and could even reactivate springs.

ACKNOWLEDGEMENTS

This project was partly funded by the Endangered Species Program (Environment Australia). Ian Pike from Eulo is thanked for sharing his enthusiasm, time and fine date wine. The landholders of all relevant properties are thanked for their kind assistance, without which the surveys would not have been possible. The Department of Natural Resources and Mines provided information on bores in the region and historical maps which were valuable in locating springs. Steve Eastaugh's companionship and assistance in the field is also greatly appreciated.

TABLE 2. Bores from the Eulo 1:250 000 map sheet for which pre-1913 and recent flow rates are available. Flow rates provided are the maximum when uncontrolled. Initial flow rates of named bores are sourced from Dunstan (1913). Bore information is courtesy the Department of Natural Resources and Mineswith some initial flow rates sourced from Dunstan (1913). 'Controlled' applies to bores that have been capped.

Bore Name/ number	Pre-1913 flow (L/day)	Recent year of inspection	Bore status	Recent flow (L/day)	% pre-1913 flow
4560	285,120	1992	Controlled	144,288	50.6
Mulgar(9) 4553	998,011	1992	Un-controlled	340,416	34.1
1491	31,104	1956	Controlled	8,640	27.8
Kungie 4550	1,168,655	1972	Un-controlled	304,992	26.1
403	16,498,080	1987	Controlled	4,192,128	25.4
Tunka 1617	13,608	1997	Un-controlled	3,456	25.4
Taleroo 1619	340,200	1937	Controlled	76,896	22.5
1831	307,584	1992	Controlled	63,936	20.8
Wooregym 1488	217,728	1974	Un-controlled	43,200	19.8
Woolshed(2) 1616	90,720	1997	Un-controlled	17,280	19.0
4547	2,445,984	1993	Un-controlled	315,360	12.9
2272	5,069,088	1987	Un-controlled	595,296	11.7
4551	12,274,848	1992	Controlled	1,294,272	10.5
1821	5,908,896	1992	Controlled	610,848	10.3
4552	1,249,344	1982	Un-controlled	67,392	5.4
2276	6,590,592	1985	Un-controlled	330,912	5.0
Colanya 1613	408,240	1979	Un-controlled	19,872	4.9
Bingara 1486	181,440	1997	Un-controlled	6,912	3.8
4561	5,227,200	1982	Un-controlled	145,152	2.8
402	11,643,264	1987	Un-controlled	203,904	1.8
Tunca 1487	90,720	1997	Ceased	0	0
Tarko 1490	45,360	1911	Ceased	0	0
Woolshed 1614	77,112	1969	Ceased	0	0
Caiwarro 1820	113,400	1950	Ceased	0	0
1822	12,960	1911	Ceased	0	0
2275	432,000	1928	Controlled	0	0
Ooliman 2427	127,008	1960	Ceased	0	0
2429	104,544	1937	Ceased	0	0
Mulgar(11) 4554	4,091,904	1943	Ceased	0	0
Boortra 4556	12,273,120	1959	Ceased	0	0
Tinnenburra(1) 4558	4,089,312	1915	Ceased	0	0
Mulgar(10) 4559	136,080	1974	Ceased	0	0
Total	92,543,226			8,785,152	9.5

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